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IMAGE READING DEVICE

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IMAGE READING DEVICE

[Kazo yomitori sochi]

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[There are no amendments to this patent.]

Claims /2*

1. A type of image reading device characterized by the following facts: in this image reading device, while light is irradiated on the original, scanning is performed, the reflected light is imaged on a solid-state image pickup device, and the image information of the original is converted into a one-dimensional electrical signal for reading; in this image reading device, the solid-state image pickup device has at least two line sensors, which have the same sampling pitch and different phases, set integrally on it.

2. A type of image reading device characterized by the following facts: in this image reading device, while light is irradiated on the original, scanning is performed, the reflected light

* [Numbers in the margin indicate pagination in the foreign text.]

is imaged on a solid-state image pickup device, and the image information of the original is converted into a one-dimensional electrical signal for reading; in this image reading device, the solid-state image pickup device has a pair of line sensors, which have the same sampling pitch and different phases, set integrally on it.

3. The image reading device described in Claim 2 characterized by the fact that the phases of said pair of line sensors are about 180° [from each other], and they have nearly the same size and pitch of pixels.

4. A type of image reading device characterized by the following facts: in this image reading device, while light is irradiated on the original, scanning is performed, the reflected light is imaged on a solid-state image pickup device, and the image information of the original is converted into a one-dimensional electrical signal for reading; in this image reading device, the solid-state image pickup device has a pair of line sensors, which have the same sampling pitch and phases different from each other by about 180°, set integrally on it, a delay means that delays the signal of one of said pair of line sensors by an amount corresponding to the spacing of said pair of line sensors in the secondary scanning direction, an interpolating means that interpolates the delayed outputs with each other, and a filtering means that filters the image data interpolated with said interpolating means; the cutoff frequency of said filtering means can be changed by means of said data output magnification rate; if the magnification is m, and the sampling pitch of one line is P_0, the frequency f_1 is $f_1 = m / (2 * P_o)$

5. A type of image reading device characterized by the following facts: in this image reading device, while light is irradiated on the original, scanning is performed, the reflected light is imaged on a solid-state image pickup device, and the image information of the original is converted into a one-dimensional electrical signal for reading; in this image reading device, the solid-state image pickup device has a pair of line sensors, which have the same sampling pitch and phases different from each other by about 180°, set integrally on it, a delay means that delays the signal of one of said pair of line sensors by an amount corresponding to the spacing of said pair of line sensors in the secondary scanning direction, an interpolating means that interpolates the delayed outputs with each other, a filtering means that filters the image data interpolated with said interpolating means, and a re-sampling means that interpolates said filtered image data corresponding to the magnification of the output image and re-samples the image data.

6. A type of image reading device characterized by the following facts: in this image reading device, while light is irradiated on the original, scanning is performed, the reflected light is imaged on a solid-state image pickup device, and the image information of the original is converted into a one-dimensional electrical signal for reading; in this image reading device, the solid-state image pickup device has a pair of line sensors, which have the same sampling pitch and phases different from each other by about 180°, set integrally on it, a delay means that delays

the signal of one of said pair of line sensors by an amount corresponding to the spacing of said pair of line sensors in the secondary scanning direction, an interpolating means that interpolates the delayed outputs with each other, a filtering means that filters the image data interpolated with said interpolating means, and a region judging means that has said interpolated image data input and performs region judgment for the letter portion, mesh portion, picture portion, etc.; based on the judgment result of said region judging means, said filtering means changes the cutoff frequency or frequency characteristics.

7. A type of image reading device characterized by the following facts: in this image reading device, while light is irradiated on the original, scanning is performed, the reflected light is imaged on a solid-state image pickup device, and the image information of the original is converted into a one-dimensional electrical signal for reading; in this image reading device, the solid-state image pickup device has a pair of line sensors, which have the same sampling pitch and phases different from each other by about 180°, and a delay means that delays for an amount corresponding to the spacing obtained by subtracting 1/2 the read pitch in the secondary scanning direction from the spacing of said pair of line sensors in the secondary scanning direction.

Detailed explanation of the invention

[0001]

Industrial application field

This invention pertains to a type of image reading device characterized by the fact that while light is irradiated on the original, scanning is performed, the reflected light is imaged on a solid-state image pickup device, and the image information of the original is converted into a one-dimensional electrical signal for reading. More specifically, this invention pertains to a type of image reading device for a printer characterized by the fact that the image of the original is read in a discrete way.

[0002]

Prior art

For an image reading device of a system that samples the original using a CCD or another one-dimensional line sensor, the space frequency band that allows transmission of the information of the original free of distortion is up to 1/2 the sampling frequency of the CCD (known as Nyquist frequency). When information of a frequency band over said Nyquist frequency is input to the CCD, aliasing distortion makes it impossible to produce a correct reproduction of the information of the original, and moiré, blotting of color of the fine line portion, and other image quality degradation take place.

[0003]

For example, for a 400-dpi scanner, since the sampling pitch is 63.5 μm, the sampling frequency is about 15.7 lines/mm, and the Nyquist frequency is about 7.9 lines/mm. When a frequency component over said 7.9 lines/mm is contained in the original, image quality degradation takes place as moiré. Especially, for a color scanner, moiré due to colors, color deviation of fine lines, etc. take place, and degradation of the image quality is significant.

[0004]

In order to solve the aforementioned problems, several methods have been proposed by the following patent applications.

[0005]

In the method described in Japanese Kokai Patent Application No. Hei 5[1993]-196894, two types of optical low-pass filters are set in the optical path so that high-frequency components cannot enter the CCD. As a result, moiré is removed.

[0006]

In the method described in Japanese Kokai Patent Application No. Sho 59[1984]-123367, /3
two line sensors are set deviated from each other by a minute spacing in the principal scanning direction, and a high-level signal is used to reduce moiré.

[0007]

In the method described in Japanese Kokai Utility Model Application Nos. Sho 52[1977]-114556 and Sho 52[1977]-114557, in a color sensor having RGB pixels set sequentially, two lines, one having two colors and the other having one color, are set, and the 2-color line [has the two colors] is set alternately.

[0008]

In the method described in Japanese Kokai Patent Application No. Hei 3[1991]-129964, the pixel pitches of the CCD are set nonuniformly so as to suppress moiré.

[0009]

In the method described in Japanese Kokai Patent Application No. Hei 4[1992]-111676, space filtering is performed for signals decomposed into RGB.

[0010]

Problems to be solved by the invention

For the method described in Japanese Kokai Patent Application No. Hei 5[1993]-196894, because low-pass filters are set in the optical path, it is necessary to perform high-precision manufacturing and adjustment. As a result, the price of the device increases. This is undesired.

[0011]

For the method described in Japanese Kokai Patent Application No. Sho 59[1984]-123367 in which two line sensors are set deviated a little in the principal scanning direction, because the two sensors are set separated from each other independently, their optical paths are different from each other, and, due to the influence of error in the setting of mirrors, etc. in the optical path and error in the magnification of lenses, etc., in order to ensure a correct configuration with a small deviation, adjustment should be performed at a rather high precision. This is undesired. Also, since each CCD has its own intrinsic torsion, warp, bending, pitch unevenness, etc., it is hard to correctly set the two sensors. Consequently, correct sampling may be impossible. This is undesired.

[0012]

For the method described in Japanese Kokai Patent Application No. Sho 59[1984]-123367, because a signal with a higher level is adopted, the density of the image varies, and it becomes different from that of the original. This is undesired.

[0013]

In the method described in Japanese Kokai Utility Model Application Nos. Sho 52[1977]-114556 and Sho 52[1977]-114557, because the pixels of the group corresponding to each sensor do not sample at the same position of the original, when the color information is fetched from a group of RGB pixels, for an image at a high frequency and in the edge portion of the image, deviation in position, color moiré, blotting, color deviation, etc. take place. This is undesired.

[0014]

For the method described in Japanese Kokai Patent Application No. Hei 3[1991]-129964, due to the uneven spacing of the pixel pitch of the CCD, although there is an effect in reducing moiré for the regular pattern, when reading is performed for fine lines and the edge portion of slanted lines without a regular pattern, the line width varies, and the drawing becomes rough. This is undesired.

[0015]

For the method described in Japanese Kokai Patent Application No. Hei 4[1992]-111676, because the input signal from the CCD is applied on the space filter as is, it is impossible to remove moiré caused by aliasing distortion.

[0016]

A method of removal of high frequency with a space filter after sampling is usually adopted. However, in this method, when a frequency component over the Nyquist frequency enters the CCD, because it is impossible to judge whether the spectrum is a spectrum of the image of the original or a spectrum due to aliasing distortion, it is impossible to remove the high frequency component completely. Also, when too much filtering is performed, degradation in resolution may take place, leading to degradation in the image quality.

[0017]

In the aforementioned prior art, even when aliasing distortion does not take place in a 1:1 operation, problems occur in the case of contraction. In this case, since data are thinned by means of interpolation, the sampling frequency decreases significantly, so that moiré, which does not take place in a 1:1 operation, appears. This is undesired.

[0018]

In order to reduce moiré, it is also necessary to read the original at a high density. However, when only the pixel number in the principal scanning direction of the CCD is increased, the area of the pixels themselves becomes smaller, the light receiving area decreases, the light quantity received becomes lower, and the S/N ratio degrades. This is undesired.

[0019]

The objective of this invention is to solve the aforementioned problems of the prior art by providing a type of image reading device characterized by the fact that aliasing distortion can be removed easily at a low cost.

[0020]

Another objective of this invention is to solve the aforementioned problems by performing sampling easily and correctly so as to reduce moiré without the need of high-precision adjustment.

[0021]

Yet another objective of this invention is to solve the aforementioned problems by performing sampling at the same position for RGB pixels, so that for an image with a high frequency or at the edge portion of the image, generation of position deviation, color moiré, blotting, color deviation, etc. is alleviated.

[0022]

Yet another objective of this invention is to solve the aforementioned problems by providing high-quality images free of moiré even in contraction/enlargement operations.

[0023]

Yet another objective of this invention is to solve the aforementioned problems by performing high-density reading at a low cost and without degradation in the S/N ratio.

[0024]

Means for solving the problems

In order to realize the aforementioned objectives, Claim 1 of the invention of this patent application provides a type of image reading device characterized by the following facts: in this image reading device, while light is irradiated on the original, scanning is performed, the reflected light is imaged on a solid-state image pickup device, and the image information of the original is converted into a one-dimensional electrical signal for reading; in this image reading device, the solid-state image pickup device has at least two line sensors, which have the same sampling pitch and different phases, set integrally on it.

[0025]

Claim 2 of this patent application provides a type of image reading device characterized by the following facts: in this image reading device, while light is irradiated on the original, scanning is performed, the reflected light is imaged on a solid-state image pickup device, and the image information of the original is converted into a one-dimensional electrical signal for reading; in this image reading device, the solid-state image pickup device has a pair of line /4
sensors, which have the same sampling pitch and different phases, set integrally on it.

[0026]

Claim 3 of this patent application is characterized by the fact that the phases of said pair of line sensors are about 180° [from each other], and they have nearly the same size and pitch of pixels.

[0027]

Claim 4 of this patent application provides a type of image reading device characterized by the following facts: in this image reading device, while light is irradiated on the original, scanning is performed, the reflected light is imaged on a solid-state image pickup device, and the image information of the original is converted into a one-dimensional electrical signal for reading; in this image reading device, the solid-state image pickup device has a pair of line sensors, which have the same sampling pitch and phases different from each other by about 180°, set integrally on it, a delay means that delays the signal of one of said pair of line sensors by an amount corresponding to the spacing of said pair of line sensors in the secondary scanning direction, an interpolating means that interpolates the delayed outputs with each other, and a filtering means that filters the image data interpolated with said interpolating means; the cutoff frequency of said filtering means can be changed by means of said data output magnification; if the magnification is m, and the sampling pitch of one line is P_0, the frequency f_1 is $f_1=m/(2xP_0)$.

[0028]

Claim 5 of this patent application provides a type of image reading device characterized by the following facts: in this image reading device, while light is irradiated on the original, scanning is performed, the reflected light is imaged on a solid-state image pickup device, and the image information of the original is converted into a one-dimensional electrical signal for reading; in this image reading device, the solid-state image pickup device has a pair of line sensors, which have the same sampling pitch and phases different from each other by about 180°, set integrally on it, a delay means that delays the signal of one of said pair of line sensors by an amount corresponding to the spacing of said pair of line sensors in the secondary scanning direction, an interpolating means that interpolates the delayed outputs with each other, a filtering means that filters the image data interpolated with said interpolating means, and a re-sampling means that interpolates said filtered image data corresponding to the magnification of the output image and re-samples the image data.

[0029]

Claim 6 of this patent application provides a type of image reading device characterized by the following facts: in this image reading device, while light is irradiated on the original, scanning is performed, the reflected light is imaged on a solid-state image pickup device, and the image information of the original is converted into a one-dimensional electrical signal for reading; in this image reading device, the solid-state image pickup device has a pair of line sensors, which have the same sampling pitch and phases different from each other by about 180°,

set integrally on it, a delay means that delays the signal of one of said pair of line sensors by an amount corresponding to the spacing of said pair of line sensors in the secondary scanning direction, an interpolating means that interpolates the delayed outputs with each other, a filtering means that filters the image data interpolated with said interpolating means, and a region judging means that has said interpolated image data input and performs region judgment for the letter portion, mesh portion, picture portion, etc.; based on the judgment result of said region judging means, said filtering means changes the cutoff frequency or frequency characteristics.

[0030]

Claim 7 of this patent application provides a type of image reading device characterized by the following facts: in this image reading device, while light is irradiated on the original, scanning is performed, the reflected light is imaged on a solid-state image pickup device, and the image information of the original is converted into a one-dimensional electrical signal for reading; in this image reading device, the solid-state image pickup device has a pair of line sensors, which have the same sampling pitch and phases different from each other by about 180°, and a delay means that delays for an amount corresponding to the spacing obtained by subtracting 1/2 the read pitch in the secondary scanning direction from the spacing of said pair of line sensors in the secondary scanning direction.

[0031]

Operation

The image reading device of this invention (Claim 1) makes use of a solid-state image pickup device that has at least two line sensors, which have the same sampling pitch and different phases, set integrally on it. Consequently, a low cost can be realized. Also, it is easy to remove moiré caused by aliasing distortion. In addition, there is no need to perform adjustment at high precision.

[0032]

The image reading device of this invention (Claim 2) makes use of a solid-state image pickup device that has a pair of line sensors, which have the same sampling pitch and different phases, set integrally on it. As a result, a low cost can be realized. Also, it is easy to remove moiré caused by aliasing distortion. In addition, there is no need to perform adjustment at high precision.

[0033]

For the image reading device of this invention (Claim 3), the phases of said pair of line sensors are about 180° [from each other], and they have nearly the same size and pitch of pixels. Consequently, the drawing does not become rough, and moiré can be reduced.

[0034]

The image reading device of this invention (Claim 4) makes use of a solid-state image pickup device having a pair of line sensors that have the same sampling pitch and phases different from each other by about 180° set integrally to read the image information of the original. It then makes use of a delay means to delay the signal of one of said pair of line sensors by an amount corresponding to the spacing of said pair of line sensors in the secondary scanning direction. Also, it interpolates the delayed outputs with each other, and filters the image data interpolated with said interpolating means at a cutoff frequency of said filtering means that can be changed by means of said data output magnification. If the magnification is m, and the sampling pitch of one line is P_0, the cutoff frequency f_1 is $f_1=m/(2xP_0)$. Consequently, by filtering the interpolated image data at said cutoff frequency, it is possible to obtain a signal free of aliasing distortion, and, at the same time, the image is free of moiré even after thinning due to interpolation.

[0035]

The image reading device of this invention (Claim 5) makes use of a solid-state image pickup device that has a pair of line sensors, which have the same sampling pitch and phases different from each other by about 180°, set integrally on it, to read the image information of the original. Also, it delays the signal of one of said pair of line sensors by an amount corresponding to the spacing of said pair of line sensors in the secondary scanning direction, interpolates the delayed outputs with each other, filters the image data interpolated with said interpolating means, and interpolates said filtered image data corresponding to the magnification of the output image and re-samples the image data. As a result, a signal free of aliasing distortion is obtained, and, at /5
the same time, the image is free of moiré even in contraction/enlargement.

[0036]

The image reading device of this invention (Claim 6) makes use of a solid-state image pickup device that has a pair of line sensors, which have the same sampling pitch and phases different from each other by about 180°, set integrally on it, to read the image information of the original. Also, it delays the signal of one of said pair of line sensors by an amount corresponding to the spacing of said pair of line sensors in the secondary scanning direction, interpolates the

delayed outputs with each other, inputs said interpolated image data and performs region judgment for the letter portion, mesh portion, picture portion, etc. Based on the judgment result of said region judging means, said filtering means changes the cutoff frequency or frequency characteristics in filtering said interpolated image data. As a result, an optimum image quality can be realized for each of the regions, that is, the letter portions, mesh portions, picture portions, etc.

[0037]

The image reading device of this invention (Claim 7) makes use of a solid-state image pickup device that has a pair of line sensors, which have the same sampling pitch and phases different from each other by about 180°, to read the image information of the original, and it delays for an amount corresponding to the spacing obtained by subtracting 1/2 the read pitch in the secondary scanning direction from the spacing of said pair of line sensors in the secondary scanning direction. As a result, the structure has a low cost, and it can perform high-density read operation.

[0038]

Application examples

In the following, this invention will be explained in more detail with reference to Application Examples 1 and 2, in which the image reading device of this invention is applied in a color scanner, illustrated with figures.

[0039]

Application Example 1

Figure 1 is a schematic block diagram illustrating the color scanner in Application Example 1. Analog outputs from the various reading lines of CCD (101) as a solid-state image pickup device are converted into digital signals by means of A/D converter (102).

[0040]

As shown in Figure 2, for CCD (101) as the main portion of this invention, in each pair of reading lines (the pair of lines R1 and R2, the pair of lines G1 and G2, and the pair of lines B1 and B2), the reading lines are set with a distance (spacing) of L2 in the secondary scanning direction, and they are shifted from each other by 1/2 of pixel pitch P (180° in phase) in the principal scanning direction, with the same pitch and the same pixel size for these reading lines set integrally.

[0041]

Three pairs of the reading lines are set with a distance of L1 from each other in the secondary scanning direction. They have color decomposition filters R, G, B, respectively, and the constitution is for color reading.

[0042]

Among the digital signals output from A/D converter (102), the signals of lines R1, G1 and B1 are sent to delay memory (103) for a delay corresponding to the distance (L2) between the reading lines in each pair in the secondary scanning direction. Consequently, the first-line data (lines R1, G1, B1) and the second-line data (lines R2, G2, B2) become the read signal of the same line of the original.

[0043]

Then, the data of G and B are sent to delay memory (104) for delaying corresponding to the distance between color pixels (L1 or 2xL1), and the image signals of R, G, B at the same position of the original are obtained.

[0044]

Then, the data are subject to shading correction, γ correction, etc. by means of correcting circuit (105). Also, said correcting circuit (105) may be set ahead of delay memories (103), (104).

[0045]

Then, by means of interpolating circuit (106), the data of the two lines, that is, the first and second lines, are interpolated with each other. At this time point, the image data are sampled at a virtual double sampling frequency. Also, in Application Example 1, a clock twice as fast as the CCD clock is used to select the data alternately to obtain the interpolating data.

[0046]

The interpolated data output from interpolating circuit (106) are sent to region judging circuit (107) and filter circuit (108). In region judging circuit (107), judgment is performed on the regions, such as letter portions, mesh portions, picture portions, etc. The result is notified to filter circuit (108) and color conversion/color correction/gradation correcting circuit (110), and parameters of the circuits are changed.

[0047]

By means of magnification and a parameter for correcting the MTF of RGB using lenses, filter circuit (108) determines the frequency characteristics, and performs filtering of the interpolated data.

[0048]

In re-sampling/interpolating circuit (109), interpolation and re-sampling are performed corresponding to the magnification, so that an RGB signal converted into a sampling frequency that allows final output is output.

[0049]

Based on this signal, by means of subsequent color conversion/color correction/gradation correcting circuit (110), K, C, M, Y signals are obtained and are output to the printer side.

[0050]

On the printer side, these signals are subject to video processing and modulation treatment with video processing/modulation circuit (111), and LD is driven through LD driver (112). Also, instead of direct output to the printer, it is also possible to adopt the following scheme: when filing treatment is carried out, RGB signals after re-sampling are temporarily stored in an image memory not shown in the figure, followed by filing in a prescribed memory device either directly or after compression treatment and conversion treatment to Lab space.

[0051]

In the following, explanation will be provided for the operation of the aforementioned measurement in the case of a specific original as an example. First of all, explanation will be provided for the case when initially the pixel density of the CCD is 400 dpi (with a sampling pitch of 63.5 μm and sampling frequency at about 15.7 lines/mm for the surface of the original), the frequency of the read original is 12 lines/mm (about 1.5 times the Nyquist frequency), and the magnification is 100%.

[0052]

As shown in Figure 3(a), on the surface of the original, the pixels of CCD (101) are set in a configuration with a pitch of 63.5 μm. In Figure 3(a), the pixels are divided into a first line and second line of pixels. As explained above, the signal is delayed with delay memory (103). Consequently, in this case, the signal of the same line in the secondary scanning direction is obtained. /6

[0053]

When said configuration of CCD (101) is used in reading an original (a multi-line chart), the area of the portion where the opening of CCD (101) and the multi-line chart are overlapped with each other (in the figure, the portion where the hatched portions are overlapped) is obtained as a signal output. Figure 3(b) illustrates the output of the reading lines. They exhibit moiré with an inverted phase of about 4 lines/mm.

[0054]

This can be explained for the frequency region. As shown in Figure 4(a), the spectrum due to aliasing distortion appears at the site of about 4 lines/mm. In the figure, f_n represents the Nyquist frequency of about 8 lines/mm, and f_s represents the sampling frequency and is about 16 lines/mm.

[0055]

Then, by means of interpolating circuit (106), the data of the first and second lines are interpolated to each other to form the solid line shown in Figure 3(c). For the spectral state in this case, since the virtual sampling frequency is doubled, as shown in Figure 4(b), there is no overlapping due to aliasing distortion, and the state is free of generation of moiré. Also, as shown in the figure, f_n' represents the virtual Nyquist frequency after interpolation and is about 16 lines/mm, and f_s represents the sampling frequency after interpolation, and it is about 32 lines/mm.

[0056]

If the magnification is 100%, as shown in Figure 4(b), filtering is performed with the filtering characteristics having a cutoff frequency near the Nyquist frequency (about 8 lines/mm) for a row of reading line, obtaining data free of moiré as shown in Figure 3(c). In the frequency region, as shown in Figure 4(c), the DC component alone is left, and an average density of the original is obtained. This filtering is carried out by means of a digital filter by means of a convolution method or the like.

[0057]

Then, if the magnification is 100%, by means of re-sampling/interpolating circuit (109), re-sampling is carried out at the original sampling pitch of 63.5 μm. In practice, 1/2 thinning is carried out. Figure 3(c) illustrates the data after re-sampling. Figure 4(d) illustrates the spectral state in this case. Within the Nyquist frequency f_n=8 lines/mm, the aliasing spectrum is removed,

and image data free of moiré are obtained. Even for an original over the Nyquist frequency, a signal with little moiré is obtained.

[0058]

In the following, explanation will be provided for the case when the frequency of the read original is 6 lines/mm (0.75 times the Nyquist frequency), and the influence of the frequency will be considered. As shown in Figure 5(a), sampling is carried out, and the data when the number of sampling pixels is 100 become as shown in Figures 6(a) and 7(a). The state of the spectrum in this case becomes as shown in Figures 6(b) and 7(b).

[0059]

As shown in Figures 6(b) and 7(b), in the Nyquist frequency (f_n=8 lines/mm), the high-frequency component of aliasing enters at the site of about 4 Hz, and it interferes with the frequency of the original itself at 6 Hz, generating moiré at about 4 Hz (=6-4) [sic].

[0060]

In practice, there is only a little high-frequency spectrum due to MTF of the CCD aperture (see Figure 11) and MTF of the lens. However, even in this case, within the Nyquist frequency range, interference takes place between aliasing and the frequency of the original, leading to moiré. Especially, on a color printer, color moiré takes place, and the image degrades.

[0061]

In Application Example 1, because there is overlap with the adjacent pixels, as shown in Figures 12(a), (b), MTF in the high-frequency region shown in Figure 11 becomes poorer than MTF when the pixel number is simply doubled by changing the pixel pitch from P to P/2. Consequently, the influence of high-frequency aliasing is reduced.

[0062]

Also, when region judgment treatment (treatment for separating letter portions, mesh portions, picture portions, etc.) is carried out when said moiré takes place, poor separation is likely, and this is undesired. In Application Example 1, however, since the region judgment treatment is carried out in the data interpolated state, it is possible to increase the separation precision.

[0063]

Figure 8(a) illustrates the data after interpolation of the first and second lines. Figure 8(b) illustrates the state of the spectrum in this case. As shown in the figure, the high-frequency components are separated from each other, and a moiré-free state exists. Then, in the case of 1:1 treatment, as filter treatment is performed as shown in Figure 8(b), a spectrum containing the high-frequency component as shown in Figure 9(a) is obtained. Then, thinning treatment is carried out for returning to the original sampling frequency. As shown in Figure 9(b), within the Nyquist frequency (8 lines/mm), a signal free of high-frequency aliasing distortion and with reduced moiré is obtained.

[0064]

As an example of another magnification, if the magnification is 50%, the spectrum shown in Figure 8(b) is subject to filtering with filter characteristics shown in Figure 10(a) (with cutoff frequency set at $0.5/(2 \times 0.0635) \approx 4$ lines/mm), forming a spectrum with only a DC component as shown in Figure 10(b). Then, as the data are subject to 1/4 thinning, the spectrum becomes as shown in Figure 10(c), and no moiré is generated even in the case of contraction/enlargement.

[0065]

Figure 10(d) illustrates an example of the spectrum when contraction/enlargement treatment is carried out without performing said filtering treatment. Plural aliasing distortions take place within the Nyquist frequency (f_{nR}) in the contraction/enlargement operation.

[0066]

As shown in Figure 1, a filter circuit (108) is set independently for each of RCB [sic; RGB], and each is also used for correction of the dispersion of MTF of RGB of lenses, etc. /7
As shown in Figure 13(a), MTF of the lens has dispersion for each of RGB, and differences also occur due to the image height.

[0067]

In Application Example 1, when the lens is assembled and adjusted, MTF is measured for each image height, or, plural MTF measurement patterns (see Figure 14) are set in the region of the surface of the original before reading of the original begins.

[0068]

As shown in Figure 14, the MTF measurement pattern is a black-and-white edge pattern having high contrast, and it is read on a regular base before reading of the original. Then, the

signal of the edge portion of RGB is differentiated with a differentiating circuit for each image height, followed by Fourier transformation with an FFT circuit to determine the MTF for each color. Then, with MTF of any one color taken as a reference, the ratio of the frequency is taken for MTF of the other two colors. As a result, the filter characteristics of RGB are obtained.

[0069]

For example, if MTF of G is taken as a reference, one has:
MTF characteristics of R = (MTF characteristics of G) / (MTF characteristics of R)
MTF characteristics of B = (MTF characteristics of G) / (MTF characteristics of B)

[0070]

Then, reverse Fourier transformation is performed with a reverse FFT circuit to determine the filter coefficient for each color. As this coefficient is reflected to filter circuit (108), the filter characteristics shown in Figure 13(b) are obtained. Dispersion in MTF of each color of the lens after filtering is corrected as shown in Figure 13(c), so that color moiré and blotting are reduced. Also, by means of color conversion/color correction/gradation correcting circuit (110), the precision of color conversion can also be improved. Figure 15 is a schematic block diagram illustrating correction of dispersion for MTF of said RGB.

[0071]

Filter circuit (108) may also use a display memory not shown in the figure to conduct two-dimensional filtering processing. Based on the judgment result of region judging circuit (107), said filter circuit (108) changes the parameter properly to obtain the best image in each region.

[0072]

In Application Example 1, the constitution of CCD (charge coupling device, a solid-state image pickup device) shown in Figure 2 is adopted. However, as shown in Figure 16, one may also adopt a constitution in which a block with phase deviated by 180° is set as another block. Also, for black-and-white CCD, there may be only one group of reading lines.

[0073]

Application Example 2

Figure 17 is a schematic block diagram illustrating a color scanner in Application Example 2. In this case, interpolating circuit (106) in the schematic block diagram in Application Example 1 shown in Figure 1 is substituted with interpolating filter (1701). The other features of

the constitution are the same as those of Application Example 1, and they will not be explained again.

[0074]

The analog output from each reading line of CCD (101) is converted into a digital signal with A/D converter (102). Then, among the digital signals output from A/D converter (102), the signals of lines R1, G1 and B1 are delayed corresponding to the distance of the secondary scanning of a pair of reading lines (L2: that is, 1/2 the reading pitch in the secondary scanning direction) by means of delay memory (103). As shown in Figure 18(a), a pair of reading lines is overlapped at the middle point with respect to the principal and secondary scanning directions, while the original is sampled. The sampling point in this case is shown in Figure 18(b).

[0075]

Figure 19 is a diagram illustrating the two-dimensional Nyquist frequency range in this case. In the figure, the dot-dash line indicates the Nyquist frequency range of a conventional CCD (CCD in Figure 12(a)), and the broken line indicates the Nyquist frequency range in Application Example 2. As a frequency band with double the area is obtained, generation of moiré is reduced, and high-density sampling is carried out. Also, Figures 20(a), (b) illustrate the sampling state of CCD and the sampling point.

[0076]

Then, for each datum, shading correction, γ correction, etc. are carried out with correcting circuit (105). By means of the data obtained from the delay memory of plural lines and two-dimensional interpolating filter (1701), as shown in Figure 21, the middle point is interpolated, and in both the principal and secondary scanning directions, data with double the sampling frequency are obtained. One of the obtained data is sent to region judging circuit (107) for judgment of the letter portions, mesh portions, picture portions, etc. By means of the results, it is possible to change the parameters of filter circuit (108) and the color conversion/color correction/gradation correcting circuit (110) to be explained later.

[0077]

For filter circuit (108), by means of magnification and parameters for correcting MTF of RGB with the lens, the frequency characteristics are determined, and the data of said double sampling frequency are filtered.

[0078]

In re-sampling/interpolating circuit (109), interpolation and re-sampling are carried out corresponding to the magnification, and RGB signals converted into a sampling frequency that can be finally output are output.

[0079]

Based on the obtained signals, color conversion/color correction/gradation correcting circuit (110) is then used to generate the signals of K, C, M, Y, which are output to the printer side.

[0080]

Also, on the printer side, said signals are subject to video treatment and modulation treatment with video treatment/modulation circuit (111), and the signals then drive LD through LD driver (112).

[0081]

Effect of the invention

As explained above, in the image reading device of this invention (Claim 1), while light is irradiated on the original, scanning is performed, the reflected light is imaged on a solid-state image pickup device, and the image information of the original is converted into a one-dimensional electrical signal for reading; in this image reading device, the solid-state image /8
pickup device has at least two line sensors, which have the same sampling pitch and different phases, set integrally on it. As a result, moiré due to aliasing distortion can be removed easily at a low cost. Also, there is no need to perform high-precision adjustment, and sampling can be performed easily and correctly to reduce moiré.

[0082]

In the image reading device of this invention (Claim 2), while light is irradiated on the original, scanning is performed, the reflected light is imaged on a solid-state image pickup device, and the image information of the original is converted into a one-dimensional electrical signal for reading; in this image reading device, the solid-state image pickup device has a pair of line sensors, which have the same sampling pitch and different phases, set integrally on it. As a result, moiré due to aliasing distortion can be removed easily at a low cost. Also, there is no need to perform high-precision adjustment, and sampling can be performed easily and correctly to reduce moiré.

[0083]

In the image reading device of this invention (Claim 3), the phases of said pair of line sensors are about 180° [from each other], and the pixels have nearly the same size and pitch. As a result, moiré due to aliasing distortion can be removed easily at a low cost. Also, there is no need to perform high-precision adjustment, and sampling can be performed easily and correctly to reduce moiré. In addition, the drawing does not become rough, and moiré can be reduced.

[0084]

The image reading device of this invention (Claim 4) makes use of a solid-state image pickup device having a pair of line sensors that have the same sampling pitch and phases different from each other by about 180° set integrally to read the image information of the original. It then makes use of a delay means to delay the signal of one of said pair of line sensors by an amount corresponding to the spacing of said pair of line sensors in the secondary scanning direction. Also, it interpolates the delayed outputs with each other, and filters the image data interpolated with said interpolating means at a cutoff frequency of said filtering means that can be changed by means of said data output magnification. If the magnification is m, and the sampling pitch of one line is P_0, the cutoff frequency f_l is $f_l=m/(2xP_0)$. At this cutoff frequency, the interpolated image data are filtered, so that moiré due to aliasing distortion can be removed easily and at a low cost. Also, there is no need to perform high-precision adjustment, and sampling can be performed easily and correctly to reduce moiré. In addition, while a signal free of aliasing distortion is obtained, an image free of moiré can be obtained even after thinning due to interpolation.

[0085]

The image reading device of this invention (Claim 5) makes use of a solid-state image pickup device that has a pair of line sensors, which have the same sampling pitch and phases different from each other by about 180°, set integrally on it, to read the image information of the original. Also, it delays the signal of one of said pair of line sensors by an amount corresponding to the spacing of said pair of line sensors in the secondary scanning direction, interpolates the delayed outputs with each other, filters the image data interpolated with said interpolating means, and interpolates said filtered image data corresponding to the magnification of the output image and re-samples the image data. As a result, moiré due to aliasing distortion can be removed easily and at a low cost. Also there is no need to perform high-precision adjustment, and sampling can be performed easily and correctly to reduce moiré. In addition, while a signal free of aliasing distortion is obtained, an image free of moiré can be obtained even at the time of magnification.

[0086]

The image reading device of this invention (Claim 6) makes use of a solid-state image pickup device that has a pair of line sensors, which have the same sampling pitch and phases different from each other by about 180°, set integrally on it, to read the image information of the original. Also, it delays the signal of one of said pair of line sensors by an amount corresponding to the spacing of said pair of line sensors in the secondary scanning direction, interpolates the delayed outputs with each other, inputs said interpolated image data and performs region judgment for the letter portion, mesh portion, picture portion, etc. Based on the judgment result of said region judging means, said filtering means changes the cutoff frequency or frequency characteristics in filtering said interpolated image data. As a result, moiré due to aliasing distortion can be removed easily and at a low cost. Also, there is no need to perform high-precision adjustment, and sampling can be performed easily and correctly to reduce moiré. In addition, an optimum image quantity can be realized for each of the regions, that is, letter portions, mesh portions, picture portions, etc.

[0087]

The image reading device of this invention (Claim 7) makes use of a solid-state image pickup device that has a pair of line sensors, which have the same sampling pitch and phases different from each other by about 180°, to read the image information of the original, and it delays for an amount corresponding to the spacing obtained by subtracting 1/2 the read pitch in the secondary scanning direction from the spacing of said pair of line sensors in the secondary scanning direction. As a result, moiré due to aliasing distortion can be removed easily and at a low cost. Also, there is no need to perform high-precision adjustment, and sampling can be performed easily and correctly to reduce moiré. Also, the structure has a low cost, and it can perform high-density read operation.

<u>Brief description of the figures</u>

Figure 1 is a schematic block diagram illustrating the color scanner in Application Example 1.

Figure 2 is a diagram illustrating the constitution of the CCD (solid-state imaging device) in Application Example 1.

Figure 3 is a diagram illustrating a specific operation example of Application Example 1.

Figure 4 is a diagram illustrating a specific operation example of Application Example 1.

Figure 5 is a diagram illustrating a specific operation example of Application Example 1.

Figure 6 is a diagram illustrating a specific operation example of Application Example 1.

Figure 7 is a diagram illustrating a specific operation example of Application Example 1.

Figure 8 is a diagram illustrating a specific operation example of Application Example 1.

Figure 9 is a diagram illustrating a specific operation example of Application Example 1.

Figure 10 is a diagram illustrating a specific operation example of Application /9
Example 1.

Figure 11 is a diagram illustrating an example of a conventional CCD configuration with the pixel number simply doubled.

Figure 12 is a diagram illustrating MTF characteristics in this invention.

Figure 13 is a diagram illustrating dispersion of MTF of RGB.

Figure 14 is a diagram illustrating the MTF measurement pattern.

Figure 15 is a schematic block diagram illustrating correction of dispersion of MTF of RGB.

Figure 16 is a diagram illustrating the constitution of another CCD (solid-state image pickup device).

Figure 17 is a schematic block diagram illustrating the color scanner in Application Example 2.

Figure 18 is a diagram illustrating the sampling state and sampling point of CCD in Application Example 2.

Figure 19 is a diagram illustrating the two-dimensional Nyquist frequency range in Application Example 2.

Figure 20 is a diagram illustrating the sampling state and sampling point of a CCD in the prior art.

Figure 21 is a diagram illustrating the data with a doubled sampling frequency in both the principal and secondary scanning directions in Application Example 2.

Explanation of part numbers

101 CCD (solid-state image pickup device)

102 A/D converter

103, 104 Delay memory

105 Correcting circuit

106 Interpolating circuit

107 Reference judging circuit (107)

108 Filter circuit

109 Re-sampling/interpolating circuit

110 Color conversion/color correction/gradation correcting circuit

1701 Interpolating filter

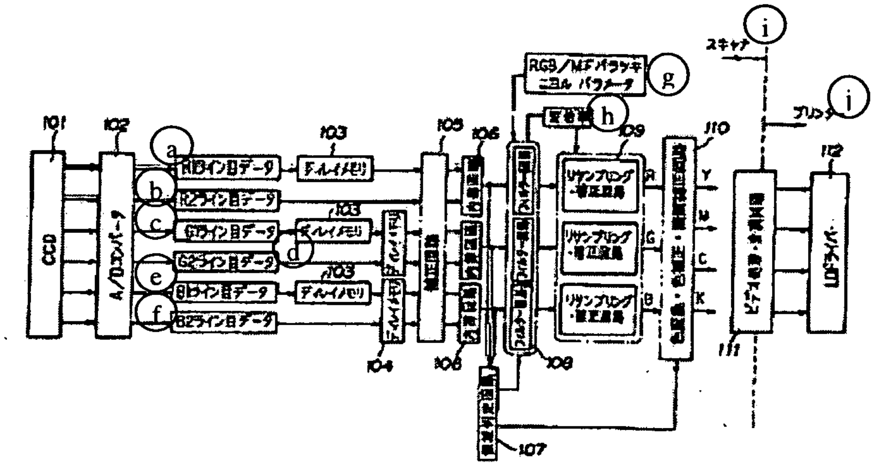

Figure 1

Key:
a Data of line R1
b Data of line R2
c Data of line G1
d Data of line G2
e Data of line B1
f Data of line B2
g Parameter depending on RGB/MIF dispersion
h Magnification
i Scanner
j Printer
102 A/D converter
103, 104 Delay memory
105 Correcting circuit
106 Interpolating circuit
107 Reference judging circuit
108 Filter circuit
109 Re-sampling/interpolating circuit
110 Color conversion/color correction/gradation correcting circuit
111 Video processing/modulation circuit
112 LD driver

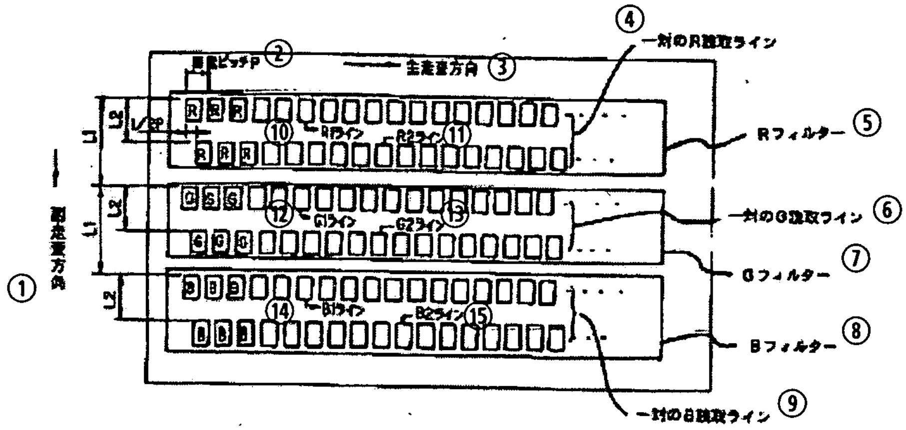

Figure 2

Key:
1 Secondary scanning direction
2 Pixel pitch P
3 Principal scanning direction
4 A pair of R reading lines
5 R filter
6 A pair of G reading lines
7 G filter
8 B filter
9 A pair of B reading lines
10 R1 line
11 R2 line
12 G1 line
13 G2 line
14 B1 line
15 B2 line

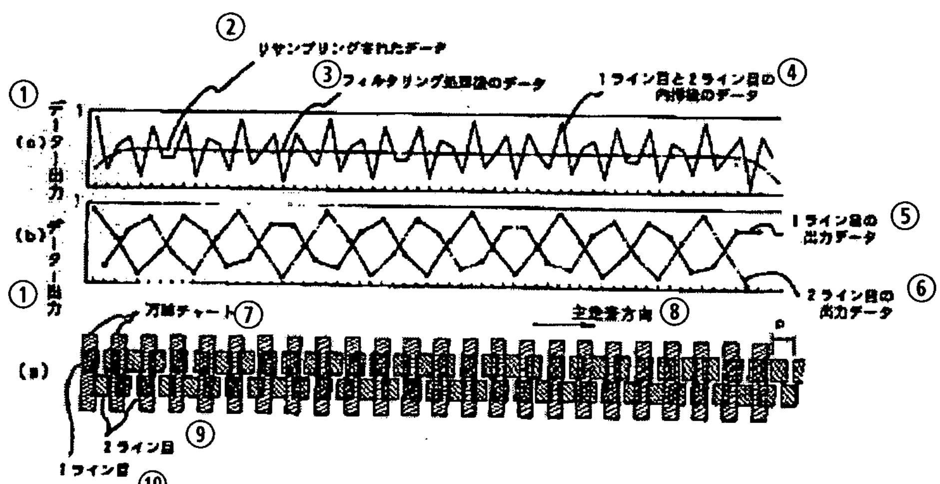

Figure 3

Key:
1 Data output
2 Re-sampled data
3 Data after filtering treatment

4 Data after interpolation of first and second lines
5 Output data of first line
6 Output data of second line
7 Multi-line chart
8 Principal scanning direction
9 Second line
10 First line

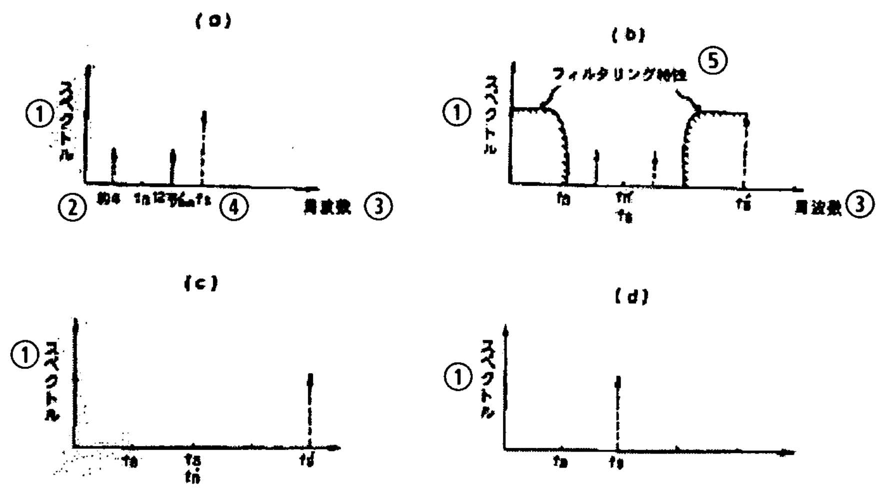

Figure 4

Key:
1 Spectrum
2 About 4
3 Frequency
4 12 lines/mm
5 Filtering characteristics

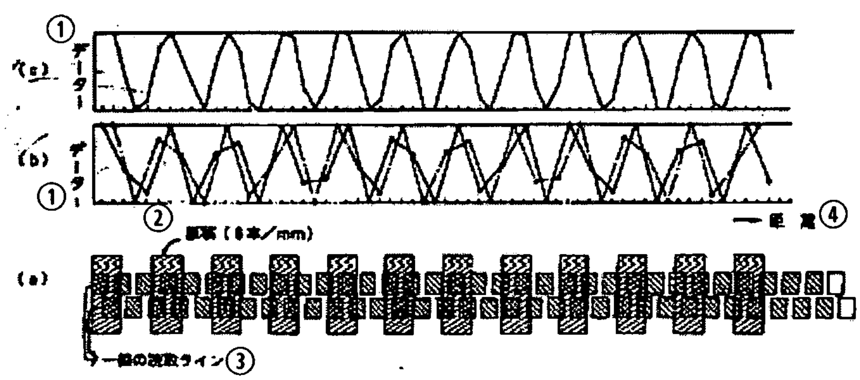

Figure 5

Key:
1 Data
2 Original (6 lines/mm)
3 A group of reading lines
4 Distance

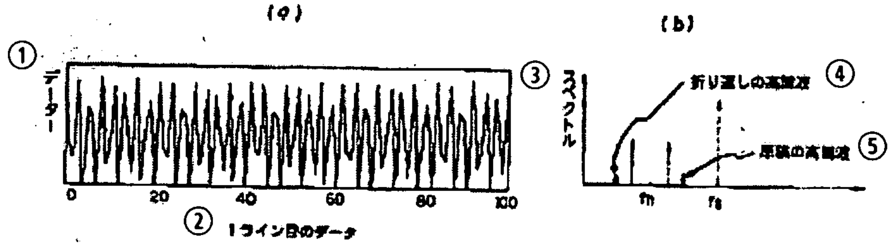

Figure 6

Key: 1 Data
2 Data of first line
3 Spectrum
4 Aliasing harmonics
5 Harmonics of original

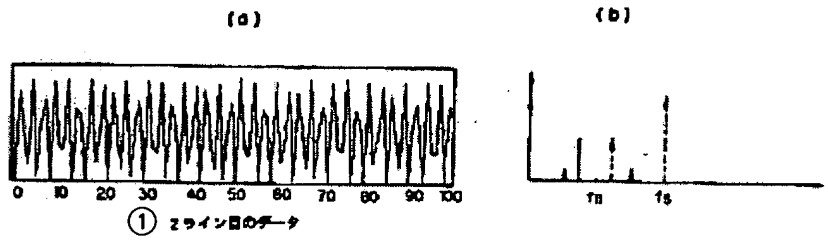

Figure 7

Key: 1 Data of second line

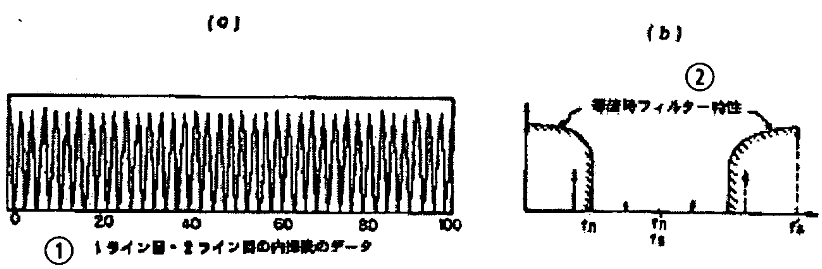

Figure 8

Key: 1 Data after interpolation of the first and second lines
2 Filter characteristics in 1:1 operation

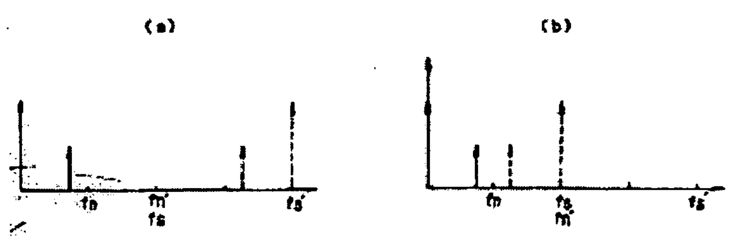

Figure 9

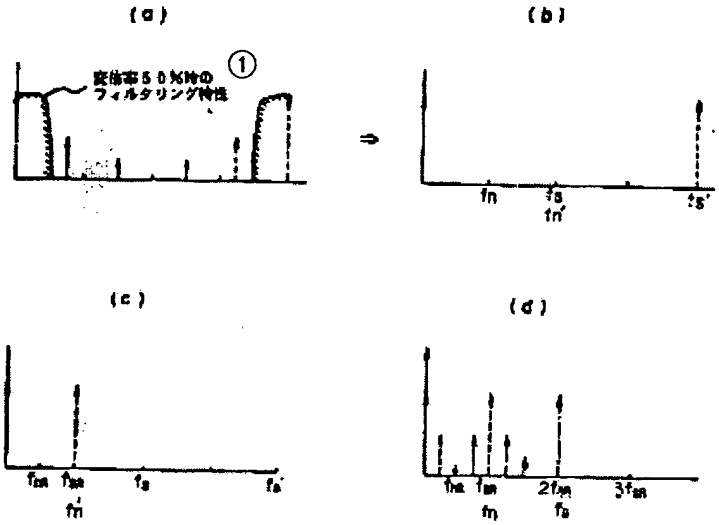

Figure 10

Key: 1 Filtering characteristics for magnification of 50%

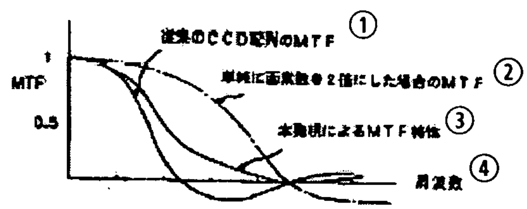

Figure 11

Key:
1 MTF of conventional CCD configuration
2 MTF when pixel number is simply doubled
3 MTF characteristics in this invention
4 Frequency

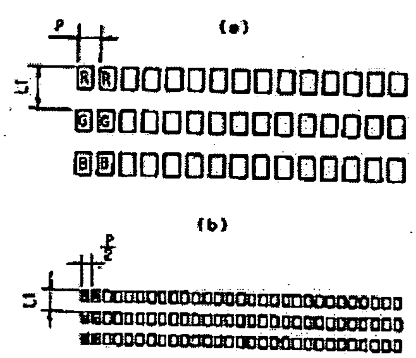

Figure 12

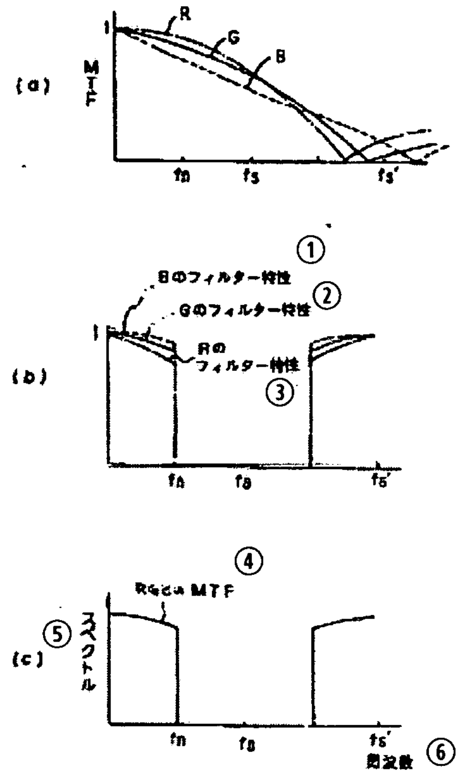

Figure 13

Key: 1 Filter characteristics of B
2 Filter characteristics of G
3 Filter characteristics of R
4 MTF of RGB
5 Spectrum
6 Frequency

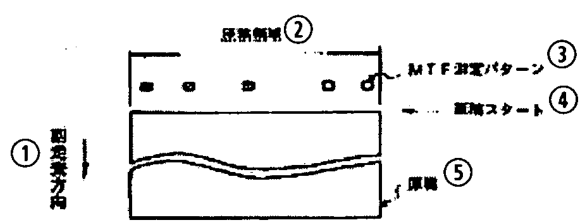

Figure 14

Key: 1 Secondary scanning direction
2 Region of original
3 MTF measurement pattern
4 Start of original
5 Original

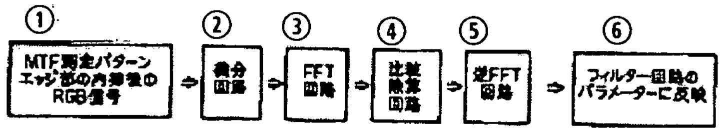

Figure 15

Key: 1 RGB signals after interpolation of the edge portion of the MTF measurement pattern
2 Differentiating circuit
3 FFT circuit
4 Comparing/dividing circuit
5 Reverse FFT circuit
6 Reflected to parameter of filter circuit

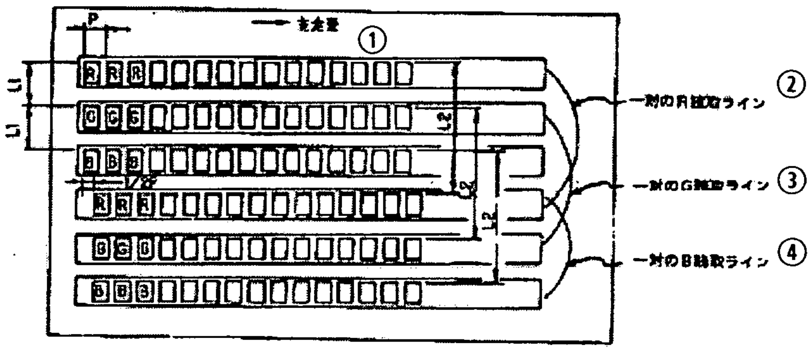

Figure 16

Key: 1 Principal scanning
2 A pair of R reading lines
3 A pair of G reading lines
4 A pair of B reading lines

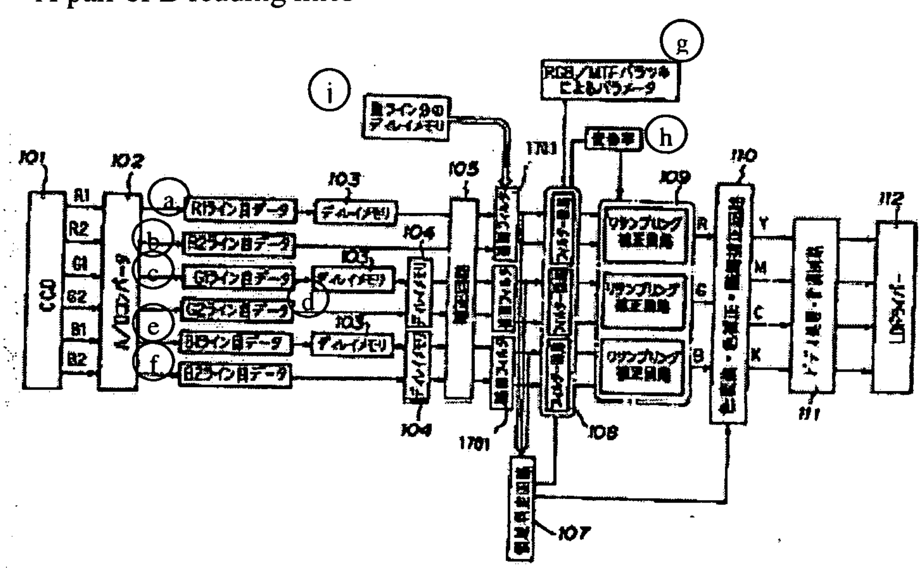

Figure 17

Key:

- a Data of line R1
- b Data of line R2
- c Data of line G1
- d Data of line G2
- e Data of line B1
- f Data of line B2
- g Parameter depending on RGB/MTF dispersion
- h Magnification
- i Delay memory for several lines
- 102 A/D converter
- 103, 104 Delay memory
- 105 Correcting circuit
- 107 Reference judging circuit
- 108 Filter circuit
- 109 Re-sampling/interpolating circuit
- 110 Color conversion/color correction/gradation correcting circuit
- 111 Video processing/modulation circuit
- 112 LD driver
- 1701 Interpolating filter

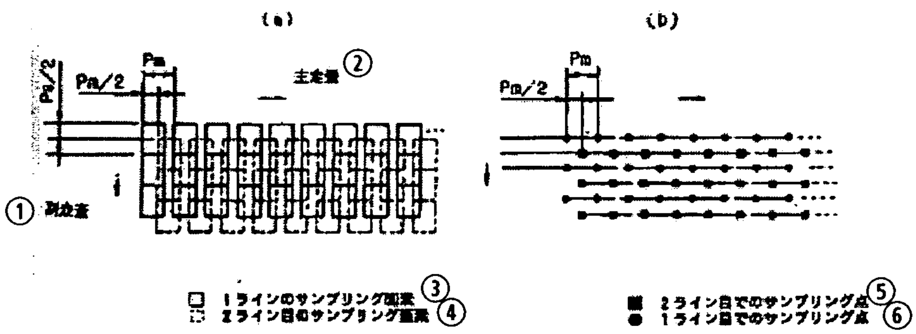

Figure 18

Key:

- 1 Secondary scanning
- 2 Principal scanning
- 3 Sampling pixels of first line
- 4 Sampling pixels of second line
- 5 Sampling points of second line
- 6 Sampling points of first line

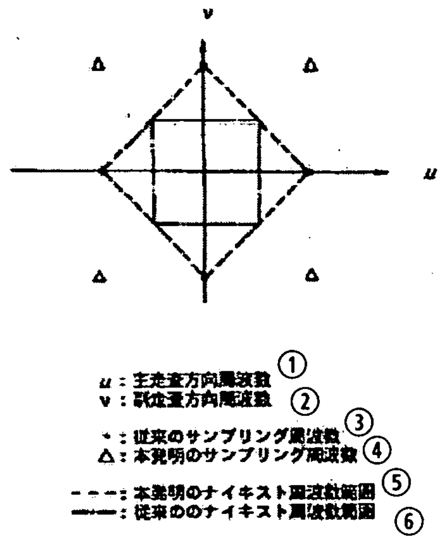

Figure 19

Key:
1 Frequency in the principal scanning direction
2 Frequency in the secondary scanning direction
3 Sampling frequency of prior art
4 Sampling frequency of this invention
5 Nyquist frequency range of this invention
6 Nyquist frequency range in prior art

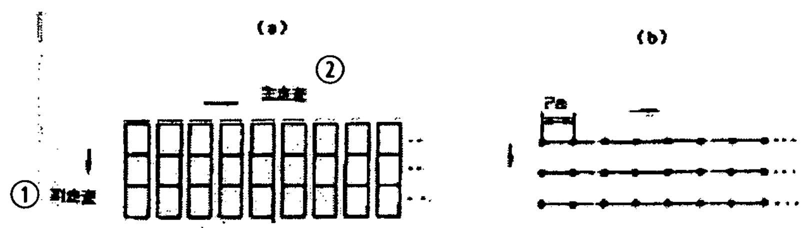

Figure 20

Key:
1 Secondary scanning
2 Principal scanning

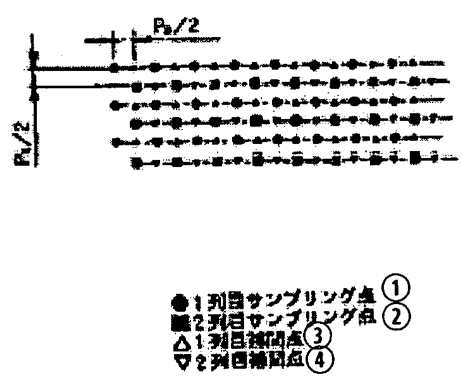

Figure 21

Key:
1 Sampling points of first row
2 Sampling points of second row
3 Interpolated points of first row
4 Interpolated points of second row